ACKNOWLEDGMENT

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Transit Performance in the I-35W Urban Corridor Demonstration Project

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The I-35W Minneapolis-St. Paul Urban Corridor Demonstration Project was designed to test (a) the effectiveness of expanding express bus route coverage and service frequency and (b) the potential of ramp metering to produce higher operating speeds. To evaluate expanding bus service and ramp metering of the I-35W project required an extensive data collection and monitoring program throughout the project. The results of this analysis clearly indicate the ability of both express bus service and ramp metering to substantially increase transit use. Further, we concluded that the freeway must have complete access control, both inbound and outbound, for ramp metering to produce high transit operating speeds. In addition, we found that express bus service exhibits a lower unit cost per kilometer than local service and, to the extent that ramp metering increases express bus-operating speeds, ramp metering produces further reductions in transit unit cost. The major conclusion of the I-35W project is that expanded bus service and ramp metering can provide a relatively low-cost technique to increase use of existing freeways and encourage diversion of travelers to environmentally desirable and energy-efficient modes of travel.

With growing awareness of limited funds to provide adequate urban-area transit, the U.S. Department of Transportation embarked on a program to identify and evaluate low-capital methods to expedite urban travel. This program consisted of about 12 Urban Corridor Demonstration Projects (UCDPs). The basic intention of the program was to focus on a particular corridor in an urban area and, through the use of low-capital techniques, increase both vehicle and person travel capacity. One such project and the topic of this paper was the I-35W UCDP in the Minneapolis-St. Paul metropolitan area. As indicated in Figure 1, the corridor extended from the Minneapolis central business district (CDB), south through densely developed residential areas of the inner city and through the outlying suburban communities that parallel I-35W. This corridor was selected because it accounts for a substantial degree of CBD-oriented travel. Furthermore, in recent years, the I-35W corridor has experienced an increased frequency and degree of congestion.

Two primary elements of the I-35W UCDP were the introduction of greatly expanded express bus service and the implementation of freeway ramp metering. The expansion of express bus service was accomplished by opening new routes and increasing frequency of express service. The ramp-metering concept includes surveillance of the roadway to compare traffic demand to available capacity. Based on relative balance of roadway supply and demand, the number of vehicles that may enter each ramp is controlled by a traffic signal; thus, access to the freeway is metered. The freeway always operates at a high level of service, assuring high-speed operation of public transit and other vehicles. In this project, transit vehicles were also given separate priority access ramps to further improve the quality and attractiveness of service.

An integral part of the demonstration project was the evaluation of each of the two major elements in satisfying certain transit objectives. For this reason, the evaluation was divided into the following three phases.

Phase	Period	Project Element
1	Fall 1972	Limited express bus service, no ramp metering
2	December 1972-Spring 1974	Full express bus service, no ramp metering
3	Spring 1974-December 1974	Full express bus service, ramp metering

Phases 1 and 2 represent the before and after condition of the installation of express bus service, and phases 2 and 3 represent the before and after situation for ramp metering. During each of the three phases, an extensive data collection effort was performed. The following objectives were established:

1. Provide more attractive transit service through increased express bus operating speeds;
2. Provide more attractive transit service through increased express bus dependability; and
3. Determine and evaluate transit operating characteristics such as patronage, revenue, and cost.

TRANSIT OPERATING SPEED

Service was made more attractive in the corridor by adding bus routes and increasing bus frequency during phase 2 and by ramp metering and giving priority freeway access to buses during phase 3.

The desirability of transit was assessed by travel

time, which previous analyses had identified as a key determination in mode choice. On the basis of scheduled travel times between downtown Minneapolis and selected locations in the I-35W corridor via local and express routes, the implementation of express services produced substantial time savings in comparison to local bus service. In phase 1, when only nine downtown express routes were operated, travel time savings ranging from 25 to 50 percent were observed at selected locations. When the number of express routes in phase 2 was increased, travel-time savings were made available to a far larger portion of corridor residents. The magnitude of the travel-time savings offered by express service relative to local service is based on the proportion of line-haul operation (primarily route length) of I-35W.

Another factor that affects travel time is the speed of the transit vehicle. Transit routes can be divided into collection, line-haul, and distribution segments, and each one should be analyzed separately. The ramp metering of I-35W affected only the line-haul segment of the route. On the basis of operating speeds observed in all three phases, ramp metering reduced transit travel times on the freeway. However, reductions in travel time on many routes were offset by increased travel times on the collection and distribution segments of express lines. For this reason, we suggest that future transit improvement projects that use ramp metering consider the entire transit route, not only the line-haul segment on the freeway. In particular, priority treatment of buses should be provided on the surface streets leading to the freeway ramps as well as on the freeway and ramps. At several locations, buses were delayed in traffic queues. To remedy this situation, express bus lanes should be extended from the ramp to adjacent surface streets beyond any traffic congestion zones. Although not a part of the I-35W UCDP, reversible bus lanes were established by local agencies during phase 3. This special treatment of buses in the Minneapolis CBD significantly increased transit vehicle speeds on the distribution portion of inbound service and the collection portion of outbound service and thereby enhanced the attractiveness of the express service.

The ramp metering of I-35W and the priority access for buses produced substantially different speed results with respect to travel direction. The speeds during peak periods by direction with and without metering were as follows:

Direction	Without Metering (km/h)	With Metering (km/h)	Increase (%)
Northbound	65	80	23
Southbound	60	60	0

All ramps in the northbound direction were metered, and thus access leading to downtown Minneapolis was completely controlled. Because southbound vehicle access was not metered at all locations, the freeway operated at a lower level of service. Thus, ramp metering can only be effective in increasing transit operating speeds if all major access points to the freeway are controlled.

TRANSIT SERVICE DEPENDABILITY

Transit service dependability was based on the assumption that buses operating on the freeway without metering are subject to congestion that, in turn, results in poor schedule adherence. For this reason, any correlation between ramp metering and improved transit dependability is based on schedule-adherence performance attributable to late arrivals. Since on-time performance before ramp metering was characterized by early arrivals, regulating vehicle access on I-35W did not improve schedule adherence. Early arrivals and departures of transit vehicles were observed throughout the project on both local and express bus routes, which indicates that this problem is caused by factors outside the scope of this study (e.g., driver supervision and revised timetables that more accurately reflect actual traffic conditions). Apparently ramp metering cannot improve schedule adherence where buses tend to operate ahead of schedule; in fact, ramp metering may have a negative effect. However, on the basis of the increase in line-haul speeds and reduction in delay time, ramp metering appears to be able to substantially improve on-time performance when buses arrive late because of traffic congestion.

TRANSIT OPERATING CHARACTERISTICS

Improvements in transit system performance are ultimately measured by changes in patronage, revenue, cost, performance, and operating effectiveness. Because system operating results largely depend on local policies regarding fares and passenger loading, no numerical objectives were specified for such transit operating characteristics. In addition, the effects of exogenous factors are difficult to isolate and, therefore, an assessment of cause-and-effect relationships for the key elements of the I-35W UCDP was limited. Although no objectives were identified, several conclusions were reached regarding the following category of transit operating statistics.

Patronage

Establishing an extensive network of express bus routes produced a substantial gain in riders in the I-35W corridor throughout the three phases of the project. The large increase in express bus riders in phase 2 (Table 1) was accompanied by a modest decline in local patronage, which indicates some diversion of transit patrons from local service to the more desirable express bus routes. The gain on express service was more than sufficient to offset the decline in riders on local service. During phase 3 local patronage levels stabilized but express ridership continued to increase. These trends indicate that additional riders were former automobile users and possibly new tripmakers. A telephone survey conducted during the fall of 1974 indicated that 36 percent of the express transit users formerly drove but 10 percent never made the trip before. Although ridership changes between phases 1 and 2 can be attributed to the implementation of extensive express bus service, assigning passenger shifts between phases 2 and 3 to ramp metering is not possible since considerable service expansion was also undertaken in phase 3. However, the combined effect of improved express service in terms of increased route coverage, frequency, and higher transit speeds resulted in increased transit patronage.

Revenue

The trends described for patronage also apply to the generation of revenue in the corridor as given in Table 1. Of particular interest are the trends in average fare for express and local service during the three phases.

Phase	Express Fare (¢)	Local Fare (¢)
1	49	29
2	41	28
3	41	28

Figure 1. Study area of the I-35W Urban Corridor Demonstration Project.

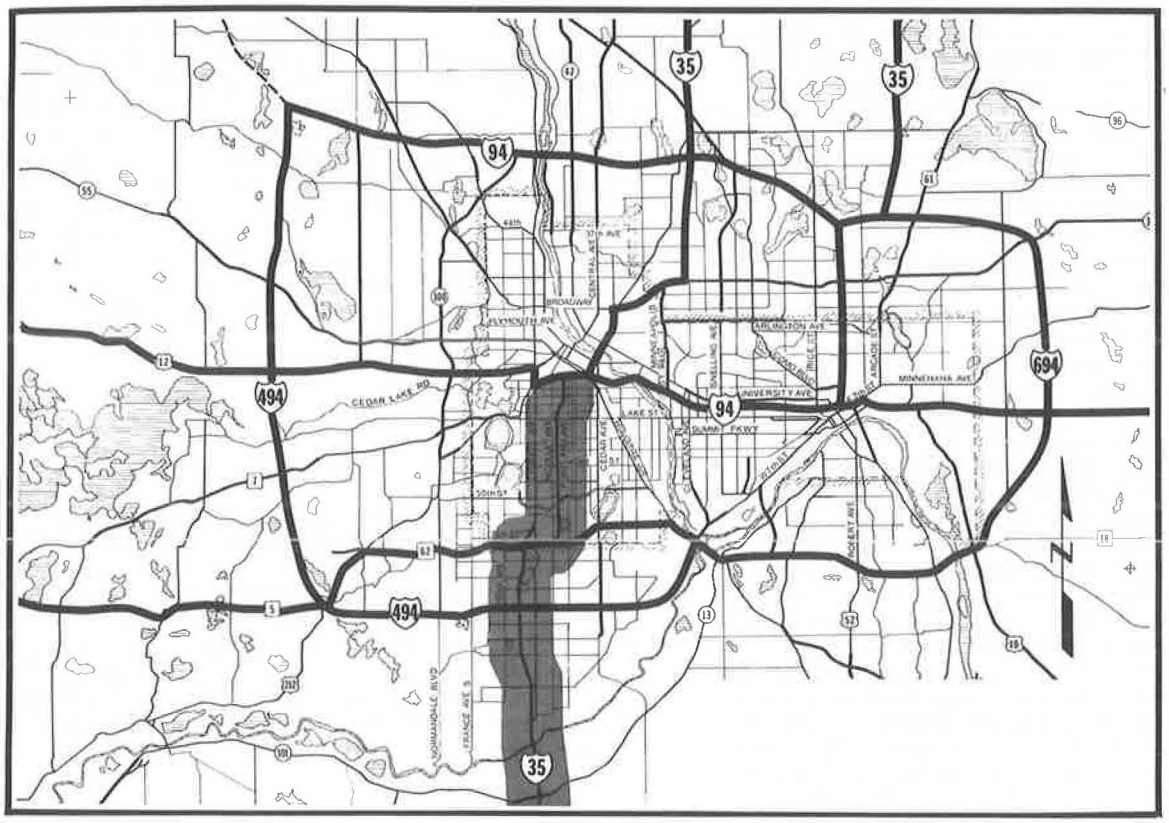

Table 1. Average weekday riders and revenue.

	Riders			Revenue ($)		
Phase	Express	Local	Total	Express	Local	Total
1	2100	22 300	24 400	1000	5400	6400
2	5400	20 800	26 200	2200	4900	7100
3	7100	20 400	27 500	2800	4800	7600

Express service exhibits higher average fares because express service is primarily used by long-distance, work-oriented riders. The initial decline in express service average fare in phase 2 resulted from the introduction of shorter express routes, many of which were not even in operation in phase 1. The local transit agency has a policy of relatively low fares on all bus service and particularly on the I-35W express routes on which the premium charge is only 5 cents regardless of trip length.

Operating Cost

Aggregate operating costs in the I-35W corridor were a manifestation of increased service levels and inflationary trends experienced throughout the 27-month study period. Given below are average weekday operating costs.

	Cost per Vehicle ($)		Cost per Vehicle-Kilometer ($)	
Phase	Express	Local	Express	Local
1	1900	6000	0.66	0.69
2	4500	6700	0.69	0.77
3	6800	7400	0.77	0.93

Based on cost per vehicle-kilometer, express service is less expensive to operate than local service, an indication of its higher operating speeds. Ramp metering encourages lower unit costs in direct proportion to the higher operating speeds on express routes produced by ramp metering. Speed-cost relationship is confirmed by the express service unit cost escalation of 17 percent (66 cents to 77 cents); the corresponding increase of local service was 35 percent (69 cents to 93 cents).

Performance

The I-35W UCDP clearly indicates that fare revenue for all service types is totally inadequate to cover operating costs. This disparity is especially true in the Minneapolis-St. Paul area where the local transit agency has adopted policies that maximize service to the public (e.g., the agency stabilized fares at relatively low levels) in spite of escalating costs. Also, decisions such as the one to purchase sufficient buses so that passengers would never have to stand have resulted in continued expansion of express service in route coverage; further, frequency in less productive transit service areas has produced higher cost/revenue ratios for all three phases. From the figures given below, we see that the cost/revenue ratio for local service is deteriorating 15 percent faster than that for express service.

Phase	Express ($)	Local ($)
1	1.86	1.12
2	2.15	1.36
3	2.47	1.54

This factor is attributable to the lower unit cost of express routes and the ability of this premium service to attract patrons. Changes in local fare policies such as

premium charges for express service could substantially improve express service operating results.

Operating Effectiveness

Of particular interest in assessing transit system performance is the relationship between the demand for service and the service supplied by the system. Two widely recognized standards to determine relative performance were evaluated in this current analysis: passengers per vehicle-kilometer and passenger-kilometers per seat-kilometer. Considerable care should be exercised in making direct comparisons of express and local service because of the fundamental differences between the two forms of service. As indicated below, local service carries more passengers per vehicle-kilometer than express service.

Phase	Express	Local
1	0.73	2.11
2	0.79	2.00
3	0.76	2.11

This is not surprising since a high proportion of express service is composed of line-haul operation that neither discharges nor picks up passengers. Because of the decision to decrease local service in phase 3, and at the same time to expand express service in less productive transit service areas, passengers per vehicle-kilometer ratios can be somewhat misleading. The conclusion to be reached from the I-35W UCDP is that passengers per vehicle-kilometer for competing local service can be stabilized by appropriate reductions in service to match declining ridership. On the other hand, express service has the ability to attract new riders and thus increase passengers per vehicle-kilometer. The decline in express service between phases 2 and 3 reflects the acquisition of a private bus operator and the local decision to expand express coverage and frequency to enhance service in the corridor at the expense of operating effectiveness.

An apparent conclusion is that express service is accommodating a substantial proportion of the potential downtown transit travel market to such an extent that providing new or additional services in phase 3 has detrimentally impacted existing routes through the internal diversion of riders.

In terms of passenger-kilometers per seat-kilometer, express service maintains a superior rating over local service, as shown below.

Phase	Express	Local
1	0.444	0.548
Early 2	0.438	0.508
Late 2	0.637	0.546
3	0.583	0.546

The deterioration between phases 2 and 3 for express service and recovery for local routes reflects the local policy decision previously described.

CONCLUSIONS

Certain conclusions are directly applicable to travel corridors in other metropolitan areas; some conclusions are applicable only to local corridors. For example, conclusions relating to the impact of freeway metering on transit line-haul speeds are applicable to other urban areas; however, transit financial performance is more a function of local environment including policies relating to fares and negotiated labor agreements.

On the basis of the project results and analyses, the following conclusions appear appropriate.

1. Ramp metering can produce significant increases in transit line-haul operating speeds; however, access control to the freeway must be complete to ensure attainment of higher operating speeds.
2. Provisions such as contraflow lanes in downtown should be considered when ramp metering is instituted to ensure high-speed transit operation not only on the line-haul segments of express routes, but also on the collection and distribution segments as well.
3. On the basis of reduced incidences of traffic congestion and travel-time delays, ramp metering has the potential to improve transit schedule adherence.
4. The implementation of extensive express bus service and ramp metering can produce substantial increases in transit ridership.
5. Express bus service is less costly than local service because of higher operating speeds.
6. To the extent that operating speeds on express routes are increased by ramp metering, unit costs are lowered.
7. Although express bus service exhibits a higher cost/revenue ratio than local service throughout the project, this ratio deteriorates faster for local service because express bus service is operating at a lower unit cost and express buses are attracting new passengers.
8. In terms of route coverage and frequency of service, a point may be reached at which expansion of express bus services does not produce a corresponding increase in ridership (i.e., diminishing returns).
9. If existing facilities are used and relatively modest expenditures are made, expanded express bus service and ramp metering can provide increased mobility and encourage travel on environmentally desirable and energy-efficient modes of transportation.

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